

1      **CLAIMS:**

2      1. A method of forming a roughened layer of platinum,  
3      comprising:

4              providing a substrate within a reaction chamber;  
5              flowing an oxidizing gas into the reaction chamber;  
6              flowing a platinum precursor into the reaction chamber and  
7      depositing platinum from the platinum precursor over the substrate in  
8      the presence of the oxidizing gas; and  
9              maintaining a temperature within the reaction chamber at from  
10     about 0°C to less than 300°C during the depositing.

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12      2. The method of claim 1 further comprising providing a  
13     reactant in contact with the roughened layer of platinum and utilizing  
14     the platinum to catalyze a conversion of the reactant to a product.

15  
16      3. The method of claim 1 wherein the flowing the platinum  
17     precursor comprises flowing a carrier gas carrying the platinum precursor,  
18     the carrier gas being flowed at a rate of no greater than about 30 sccm  
19     and the oxidizing gas being flowed at a rate of at least about 50 sccm.

1           4. The method of claim 1 wherein the oxidizing gas comprises  
2 at least one of O<sub>2</sub>, N<sub>2</sub>O, SO<sub>3</sub>, O<sub>3</sub>, H<sub>2</sub>O<sub>2</sub>, or NO<sub>x</sub>, wherein x has a value  
3 of from 1 to 3.

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5           5. The method of claim 1 wherein the platinum precursor  
6 comprises at least one of MeCpPtMe<sub>3</sub>, CpPtMe<sub>3</sub>, Pt(acetylacetonate)<sub>2</sub>,  
7 Pt(PF<sub>3</sub>)<sub>4</sub>, Pt(CO)<sub>2</sub>Cl<sub>2</sub>, cis-[PtMe<sub>2</sub>(MeNC)<sub>2</sub>], or platinum  
8 hexafluoroacetylacetone.

9

10          6. The method of claim 1 wherein the maintaining comprises  
11 maintaining the temperature at from about 200°C to less than 300°C.

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13          7. The method of claim 1 wherein the maintaining comprises  
14 maintaining the temperature at from about 220°C to about 280°C.

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16          8. The method of claim 1 further comprising forming an  
17 adhesion layer over the substrate and depositing the platinum onto the  
18 adhesion layer.

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1           9. The method of claim 8 wherein the adhesion layer comprises  
2           at least one of titanium nitride, iridium, rhodium, ruthenium, platinum,  
3           palladium, osmium, silver, rhodium/platinum alloy,  $\text{IrO}_2$ ,  $\text{RuO}_2$ ,  $\text{RhO}_2$ , or  
4            $\text{OsO}_2$ .

5  
6           10. The method of claim 1 further comprising flowing at least  
7           one other metal precursor into the chamber in addition to the platinum  
8           precursor, and wherein the platinum is deposited as an alloy of platinum  
9           and the at least one other metal.

10  
11          11. The method of claim 1 further comprising flowing a second  
12          metal precursor into the chamber and wherein the platinum is deposited  
13          as an alloy of platinum and the second metal.

14  
15          12. The method of claim 11 wherein the second metal is  
16          rhodium, iridium, ruthenium, palladium, osmium, or silver.

17  
18          13. The method of claim 1 wherein the platinum is deposited to  
19          a thickness of at least about 400 $\text{\AA}$ .

1           14. The method of claim 1 wherein the maintaining comprises  
2           maintaining the temperature at from about 200°C to less than 300°C,  
3           and wherein the platinum is deposited to a thickness of at least  
4           about 600Å in a time of less than about 40 seconds.

5

6           15. A method of forming a roughened layer of platinum,  
7           comprising:

8           providing a substrate within a reaction chamber;

9           flowing an oxidizing gas into the reaction chamber;

10          flowing a platinum precursor into the chamber and depositing  
11          platinum from the platinum precursor over the substrate in the presence  
12          of the oxidizing gas;

13          maintaining a temperature within the chamber at from about 0°C  
14          to less than or equal to about 280°C during the depositing, the  
15          deposited platinum having a rougher surface than it would have if the  
16          temperature were 300°C or greater during the depositing.

17

18          16. The method of claim 15 wherein the deposited platinum  
19          forms a continuous layer over a surface area that is at least  $4 \times 10^6$   
20          square Angstroms.

1           17. The method of claim 15 wherein the deposited platinum is  
2           hemispherical grain platinum.

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4           18. A method of forming a capacitor, comprising:  
5           providing a substrate within a reaction chamber;  
6           flowing a first oxidizing gas into the reaction chamber;  
7           flowing a first platinum precursor into the chamber and depositing  
8           platinum from the first platinum precursor over the substrate in the  
9           presence of the first oxidizing gas while maintaining a temperature within  
10           the chamber at from about 0°C to less than 300°C, and providing the  
11           deposited platinum into a first capacitor electrode;  
12           forming a second capacitor electrode proximate the first capacitor  
13           electrode; and  
14           forming a dielectric layer proximate the first capacitor electrode,  
15           the dielectric layer being between the first and second capacitor  
16           electrodes.

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18           19. The method of claim 18 wherein the flowing' the first  
19           platinum precursor comprises flowing a carrier gas carrying the platinum  
20           precursor, the carrier gas being flowed at a rate no greater than  
21           30 sccm and the first oxidizing gas being flowed at a rate of at least 50  
22           sccm.

1           20. The method of claim 18 wherein the forming the second  
2 capacitor electrode comprises depositing platinum from a second platinum  
3 precursor in the presence of a second oxidizing gas.

4

5           21. The method of claim 20 wherein the second platinum  
6 precursor is the same as the first platinum precursor.

7

8           22. The method of claim 20 wherein the second oxidizing gas is  
9 the same as the first oxidizing gas.

10

11          23. The method of claim 20 further comprising flowing a second  
12 metal precursor into the chamber with the first platinum precursor, and  
13 wherein the platinum is deposited as an alloy of platinum and the  
14 second metal.

15

16          24. The method of claim 23 wherein the second metal is  
17 rhodium, iridium, ruthenium, palladium, osmium, or silver.

18

19          25. The method of claim 18 further comprising forming an  
20 adhesion layer over the substrate and depositing the platinum onto the  
21 adhesion layer.

1           26. The method of claim 25 wherein the adhesion layer  
2           comprises at least one of titanium nitride, iridium, rhodium, ruthenium,  
3           platinum, palladium, osmium, silver, rhodium/platinum alloy,  $\text{IrO}_2$ ,  $\text{RuO}_2$ ,  
4            $\text{RhO}_2$ , or  $\text{OsO}_2$ .

5  
6           27. The method of claim 18 wherein the maintaining comprises  
7           maintaining the temperature at from about  $200^\circ\text{C}$  to less than  $300^\circ\text{C}$ .

8  
9           28. The method of claim 18 wherein the maintaining comprises  
10          maintaining the temperature at from about  $220^\circ\text{C}$  to about  $280^\circ\text{C}$ .

11  
12          29. A circuit comprising:

13           a semiconductive substrate; and  
14           a roughened platinum layer over the substrate, the roughened  
15          platinum layer comprising hemispherical grain platinum.

16  
17          30. A circuit comprising:

18           a semiconductive substrate; and  
19           a roughened platinum layer over the substrate, the roughened  
20          platinum layer being continuous over an area of the substrate that  
21          comprises at least about  $4 \times 10^6$  square Angstroms and comprising  
22          pedestals that are at least about  $300\text{\AA}$  tall within the area.

1           31. The circuit of claim 30 wherein the platinum layer comprises  
2           hemispherical grain platinum.

3  
4           32. The circuit of claim 30 wherein the area of the substrate  
5           comprises a square.

6  
7           33. A circuit comprising:  
8           a semiconductive substrate; and  
9           a roughened platinum layer over the substrate, the roughened  
10          platinum layer having a continuous surface characterized by columnar  
11          pedestals having heights greater than or equal to about one-third of a  
12          total thickness of the platinum layer.

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14          34. The circuit of claim 33 wherein the platinum layer has a  
15          thickness of at least about 600Å.

16  
17          35. The circuit of claim 33 wherein the platinum layer has a  
18          thickness of greater than or equal to about 400Å.

19  
20          36. The circuit of claim 33 wherein the platinum layer has a  
21          thickness of greater than or equal to about 100Å.

1           37. The circuit of claim 33 further comprising an adhesion layer  
2        between the platinum layer and the substrate, the adhesion layer  
3        comprising at least one of titanium nitride, iridium, rhodium, ruthenium,  
4        platinum, palladium, osmium, silver, rhodium/platinum alloy,  $\text{IrO}_2$ ,  $\text{RuO}_2$ ,  
5         $\text{RhO}_2$ , or  $\text{OsO}_2$ .

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7           38. The circuit of claim 33 wherein the pedestals terminate in  
8        dome-shaped tops.

9

10           39. The circuit of claim 33 wherein the pedestals terminate in  
11        hemispherical tops.

12

13           40. A capacitor comprising:

14        a first capacitor electrode;

15        a second capacitor electrode;

16        a dielectric layer between the first and second capacitor electrodes;

17        and

18           wherein at least one of the first and second capacitor electrodes  
19        comprises a roughened platinum layer, the roughened platinum layer  
20        having a thickness of from about 400 $\text{\AA}$  to about 1000 $\text{\AA}$  and comprising  
21        pedestals that are at least about 300 $\text{\AA}$  tall.

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23

1           41. The capacitor of claim 40 wherein the roughened platinum  
2       layer comprises hemispherical grain platinum.

3  
4           42. The capacitor of claim 40 wherein the roughened platinum  
5       layer is over a surface and is continuous over an area of the surface  
6       that is at least about  $4 \times 10^6$  square Angstroms.

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8           43. The capacitor of claim 42 wherein the area comprises a  
9       square.

10  
11          44. A capacitor comprising:  
12        a first capacitor electrode;  
13        a second capacitor electrode;  
14        a dielectric layer between the first and second capacitor electrodes;  
15        and

16           wherein at least one of the first and second capacitor electrodes  
17       comprises a roughened platinum layer, the roughened platinum layer  
18       having a continuous surface characterized by columnar pedestals having  
19       heights greater than or equal to about one-third of a total thickness of  
20       the platinum layer.

1           45. The capacitor of claim 44 wherein both capacitor electrodes  
2 comprise platinum, but only one of the capacitor electrodes comprises  
3 the roughened platinum layer.

4

5           46. The capacitor of claim 44 wherein both capacitor electrodes  
6 comprise roughened platinum layers.

7

8           47. The circuit of claim 44 wherein the pedestals terminate in  
9 dome-shaped tops.

10

11          48. The circuit of claim 44 wherein the pedestals terminate in  
12 hemispherical tops.

13

14          49. A platinum-containing material, comprising:  
15            a substrate; and  
16            a roughened platinum layer over the substrate, the roughened  
17            platinum layer having a continuous surface characterized by columnar  
18            pedestals having heights greater than or equal to about one-third of a  
19            total thickness of the platinum layer.

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21          50. The material of claim 49 wherein the pedestals terminate in  
22 dome-shaped tops.

1           51. The material of claim 49 wherein the pedestals terminate in  
2           hemispherical tops.

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4           52. A reaction catalyst comprising hemispherical grain platinum.

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6           53. A reaction catalyst characterized by an outer surface portion  
7           of platinum comprising a plurality of columnar pedestals that are at least  
8           about 100Å tall.

9  
10          54. The catalyst of claim 53 wherein the columnar pedestals are  
11          at least about 400Å tall.

12  
13          55. The catalyst of claim 53 wherein the platinum comprises  
14          hemispherical grain platinum.

15  
16          56. The catalyst of claim 53 wherein the surface portion is  
17          continuous over a substrate and covers an area of the substrate that is  
18          at least about  $4 \times 10^6$  square Angstroms.